10-11 year old pupils' self-regulated learning and problem solving skills

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Abstract

Developing problem solving competence is one of the main goals of Mathematics Education. Self-regulated learning skills are important for success in problem solving. The aim of this paper is to present the results of a research about 10-11 years old pupils' self-regulated learning and problem solving skills and the relation between these two skills. The results show that more than three quarters of 10-11 years old pupils like Mathematics, but only the half of them likes to solve non-routine problems. The positive attitude towards Mathematics is influenced by pupils' positive experiences on solving problems and their beliefs in the utility of Mathematics in their future. Most of the pupils don't give up if they can't solve the problem, they go over the text again, they try to find similar worked examples, they ask for help. There is a mild correlation between pupils' self-control and problem solving skills, a weak correlation between pupils' attitude towards Mathematics and their problem solving skills.

Keywords

Self-regulated learning, problem solving skills, attitude to mathematics, non-routine problems

Résumé

Développer la compétence en résolution de problème est l'un des principaux objectifs de l'enseignement des Mathématiques. Les capacités d'apprentissage autorégulé sont importantes pour réussir dans la résolution de problèmes. Le but de cet article est de présenter les résultats d'une recherche sur l'apprentissage

autorégulée et les compétences de résolution de problèmes des élèves âgés de 10-11 ans et la relation entre ces deux compétences. Les résultats montrent que plus de trois quarts des élèves de 10-11 ans aiment les Mathématiques, mais seulement la moitié d'entre eux aiment résoudre des problèmes non routiniers. L'attitude positive envers les Mathématiques est influencée par des expériences positives des élèves sur la résolution de problèmes et leurs croyances en l'utilité des Mathématiques dans leur avenir. La plupart des élèves si ils ne peuvent pas résoudre le problème ne l'abandonnent pas. Ils vont sur le texte encore une fois, ils essaient de trouver des exemples similaires, ils demandent de l'aide. Il y a une légère corrélation entre les compétences d'autorégulation et de résolution de problème et une faible corrélation entre l'attitude des élèves envers les Mathématiques et leurs compétences de résolution des problèmes.

Mots-Clés

Apprentissage autorégulée, compétences de résolution de problèmes, attitudes face aux mathématiques, problèmes non routiniers

Introduction

Developing problem solving competence is one of the main goals of Mathematics Education. Self-regulated learning skills are important for success in problem solving. The paper presents the results of a research regarding 10-11 years old pupils' self-regulated learning and problem solving skills and the relation between these two skills.

Theoretical Background

Self-regulated learning includes students' metacognitive strategies for planning and controlling their cognition (Corno, 1986; Zimmerman & Pons, 1988), effort management and control, and cognitive strategies (Corno & Rohrkemper, 1985). Self-regulated learning has three phases: forethought, performance control, and self-reflection phase.

The *forethought phase* includes task analysis, activation of the motivation for solving the problem, and goal formulation. Task analysis includes the understanding of the problem; identifying the given and unknown data, the relations between these data, and the requirements of the problem; recalling prior knowledge related with the problem. For a successful problem solving pupils need to be motivated. Pupils' motivation is strongly related with their beliefs about the utility of mathematics in their future life, career, and also with the interest level of solving the concrete problem. "*One's beliefs about mathematics can determine how one chooses to approach a problem, which techniques*

will be used or avoided, how long and how hard one will work on it, and so on" (Schoenfeld, 1985, p. 45). So motivation helps pupils to plan time and effort allocation for solving the task.

The *performance control phase* includes self-control and self-monitoring of the cognitive strategies, motivation, and behaviour. Related with mathematical problem solving "control has to do with the decisions and actions undertaken in analyzing and exploring problem conditions, planning courses of action, selecting and organizing strategies, monitoring actions and progress, checking outcomes and results, evaluating plans and strategies, revising and abandoning unproductive plans and strategies, and reflecting upon all decisions made and actions taken during the course of working on a problem" (Lester, Garofalo & Kroll, 1989, p. 4). Help seeking is also an important aspect of this phase. In case of an unsuccessful problem solving pupils need to be able to ask for help.

The *self-reflection phase* includes self-judgment and self-reaction. Self-judgment is one's evaluation on his/her performance and recognition of the relationship between the achieved performance level and the quality of the learning process (Zimmerman, 2000). "*The more students can take responsibility for their own learning, the more likely they are to attribute success to their own efforts. If students believe that their efforts will make a difference in what and how much they learn, then they are more likely to expend higher levels of effort in their studies*" (Hagen & Weinstein, 1995, p. 53). Self-reaction involves feelings about the achieved results: satisfaction or dissatisfaction (Zimmerman, 2002). When students feel satisfaction about their performance, they are more motivated to complete the task (Schunk, 1981).

Problem solving is a cognitive process while the solver finds solutions for non-routine problems. In TIMMS 2011 framework "*non-routine problems are problems that are very likely to be unfamiliar to students. They make cognitive demands over and above those needed for solution of routine problems, even when the knowledge and skills required for their solution have been learned*" (Mullis et al., 2009, p. 45).

Pólya (1945) has identified four main stages of problem solving: understanding the problem, making a plan, carrying out the plan, and reviewing the solution. In mathematics education literature similar steps are described by many researchers, as Leader and Middleton (2004) and Ridlon (2004). We could observe that these steps are in relation with the self-regulated learning phases.

Research Design

The research aimed to answer the following questions: What self-regulated learning skills primary school pupils have? What problem solving skills primary school pupils have? There is any relation between primary school pupils self-regulated learning skills and their problem solving skills?

The research was carried out during February-March 2013. In the research 160 10-11 years old pupils participated from Hungarian public schools from Romania. The researcher met the teachers in their classroom to give them the printed questionnaires and problem sheets, and to explain them the procedure. Pupils filled in the questionnaires and solved the problems in the presence of their teacher.

The research tools were a questionnaire with 26 items and a problem sheet with two problems. The items of the questionnaire are affirmations measured on a 4 point Likert scale from 1- not typical at all for me to 4- totally describes me. These items were developed based on the literature in self-regulated learning of Mathematics. Cronbach's alpha reliability for the questionnaire was .81. The problem sheet contained two logical problems, such that no mathematical notions or methods were needed for solving them, thus these problems really tested pupils' problem solving competence. The problems were formulated in the form of a multiple choice item, but pupils were asked to write down the reasoning which led to the selected solution.

RESULTS

In Table 1, 2 and 3 we grouped the items related with the forethought, performance control, and self-reflection phase of the self-regulated learning. The first four data columns contain which percentage of pupils have chosen answers "not typical at all for me", "a bit typical for me", "typical for me", respectively "totally describes me". The fifth column contains the sum of percentages from column "typical for me" and "totally describes me", in the discussion we consider this number as the percentage of those pupils who are characterized by the given behaviour.

TABLE 1

Students' behaviour in the forethought phase (from 1- not typical at all for me to 4- totally describes me)

Affirmation	1 (%)	2 (%)	3 (%)	4 (%)	Pupils who are characterized by the given behaviour (%)
I like mathematics	7.50	18.75	31.25	41.88	73.13
I will use Mathematics in my future	2.50	10.00	27.50	58.13	85.63
I like to solve thinking problems	13.75	29.38	29.38	27.50	56.88
After I read the problem, I reformulate its text with my own words	15.00	32.5	25.00	26.88	51.88
After I read the problem, I write down the data	11.25	33.75	28.13	26.88	55.01

TABLE 2

Students' behaviour in the performance control phase (from 1- not typical at all for me to 4- totally describes me)

Affirmation	1 (%)	2 (%)	3 (%)	4 (%)	Pupils who are characterized by the given behaviour (%)
During problem solving I check if I used all the given data	8.75	20.63	33.13	37.50	70.63
After I solve a problem, I check, if the solution is correct	5.63	18.13	37.50	38.13	75.63
After I solve a problem, I think about other possible methods for solving it	26.88	31.88	20.00	21.25	41.25
If I can't solve a problem, I go over the text again	3.75	8.75	28.75	58.75	87.50
If I can't solve a problem, I search for a similar worked example	17.50	22.50	28.13	31.25	59.38
If I can't solve a problem, I ask for help	6.88	32.50	26.25	33.75	60.00
If I can't solve a problem, I give up quickly	68.13	22.50	5.63	3.75	9.38
When I study a worked example, first I try to solve the problem by myself	13.13	20.63	30.00	36.25	66.25

TABLE 3

Students' behaviour in the self-reflection phase (from 1- not typical at all for me to 4- totally describes me)

Affirmation	1 (%)	2 (%)	3 (%)	4 (%)	Pupils who are characterized by the given behaviour (%)
Mathematics is difficult for me	47.50	26.25	18.75	7.50	25.75
I am a good mathematician	6.25	20.63	40.00	31.88	71.88
If I practice more, I would be better in mathematics	5.63	18.75	21.88	53.75	75.63
No matter how much time I devote for studying mathematics, I can't improve my grades	64.38	24.38	6.25	4.38	10.63
Usually I can solve the homework by myself	6.25	15.00	35.63	42.5	77.68

In Table 4, 5 and 6 we compared the results from this research with the results of two previous papers dealing with secondary school pupils' (Marchis & Balogh, 2010) and high-school pupils' (Marchis, 2012) self-regulated learning skills. The percentages from these tables represent those pupils for who the given affirmation is typical or totally describes them.

TABLE 4

Students' behaviour in the forethought phase

Affirmation	Primary (%)	Secondary (%)	High-school (%)
I like mathematics	73.13	34.11	-
I will use Mathematics in my future	85.63	67.83	41.49
After I read the problem, I reformulate its text with my own words	51.88	-	22.69
After I read the problem, I write down the data	55.01	-	27.47

TABLE 5

Students' behaviour in the performance-control phase

Affirmation	Primary (%)	High-school (%)
During problem solving I check if I used all the given data	70.63	21.49
After I solve a problem, I check, if the solution is correct	75.63	24.47
After I solve a problem, I think about other possible methods for solving it	41.25	9.25
If I can't solve a problem, I search for a similar worked example	59.38	32.53
If I can't solve a problem, I ask for help	60.00	27.77 (colleague) 14.33 (teacher)

TABLE 6

Students' behaviour in the self-reflection phase

Affirmation	Primary (%)	Secondary (%)	High-school (%)
If I practice more, I would be better in mathematics	75.63	48.45	60.00
No matter how much time I devote for studying mathematics, I can't improve my grades	10.63	23.64	11.94

Table 7 contains Pearson correlation coefficients between pupils' problem solving skills and pupils' answers on different items from the questionnaire. Table 8 contains Pearson correlation coefficients between their answers on the item "I like Mathematics" and their choices for other items of the questionnaire.

TABLE 7

Pearson correlation coefficients between pupils' problem solving skills and some of the self-regulated learning skills

	Problem solving skills
I like Mathematics	0.14*
I like to solve thinking problems	0.15*
During problem solving I check if I used all the given data	0.19**
When I study a worked example, first I try to solve the problem by myself	0.16*

* significance level 0.05, ** significance level 0.01

TABLE 8

Pearson correlation coefficients between items "I like Mathematics" and other different self-regulated learning skills

	I like Mathematics
I am a good mathematician	0.57***
I will use Mathematics in my future	0.27***
Mathematics is difficult for me	-0.43***
I like to solve thinking problems	0.53***
Usually I can solve the homework by myself	0.38***

*** significance level 0.001

DISCUSSION

Pupils' interest in Mathematics is important for a successful problem solving. Pupils, who like Mathematics usually, are intrinsically motivated for learning. Intrinsically motivated pupils focus on understanding mathematical concepts, applying mathematical rules and algorithms, solving interesting problem (Duda & Nicholls, 1992). These pupils allocate more time and effort for learning even in the absence of an extrinsic reward (Lepper, 1988). In Table 1 we could observe that almost three quarters (73.13%) of the pupils like Mathematics and more than half (51.88%) of the pupils like to solve thinking problems. There is a strong correlation between liking Mathematics and preferring logical problems (Table 8).

Much more than three quarters (85.63%) of the pupils are strongly convinced that they will use Mathematics in their future (Table 1). It is a strong correlation between items "I like mathematics" and "I will use mathematics in my future" (Table 8), so believing the utility of what they learn also motivates pupils for studying mathematics.

Comparing these results with the answers of secondary (Marchis & Balogh, 2010) and high-school (Marchis, 2012) pupils, we could observe that a much higher percentage of primary school pupils than secondary school pupils like Mathematics (73.13% vs. 34.11%, see Table 4). This result could be explained by the fact that the amount of

mathematical knowledge learnt in a class increase every year, so Mathematics becomes more difficult. Also the pupils' believe about the utility of Mathematics in their future decrease with their age (from 85.63% of primary school pupils to 67.83% of secondary school pupils and 41.49% of high-school pupils).

Another important step in the forethought phase is understanding the problem. Two ways for a better understanding are reformulating the text of the problem and writing down the data given in the problem. 51.88% of the pupils usually reformulate the text of the problem and 56.88% of the pupils extract the data of the problem (see Table 1). These results are much better than high-school pupils' results, because only 22.69% of them reformulate the problem with their own words and 27.47% of them write down the data of the problem (see Table 4).

Pupils' self-control is quite high, 70.63% of the pupils frequently checks if he/she used all of the data of the problem; 75.63% checks if the solution is correct, 41.24% tries to find another solving method too. Pupils don't give up easily if they can't solve the problems, they go over the text again (87.50%), they search for similar worked examples (59.38%), they ask for help (60.00%). Research shows that studying worked examples is an effective and efficient way of learning mathematics (Paas & van Gog, 2006). It is important, how pupils study worked examples. 66.25% of the pupils first try to solve the problem by themselves; only after this they read the solution. It is a mild correlation between this behaviour and pupils' problem solving results (Table 7). In Table 5 we could observe that 10-11 years old pupils' self-control is much higher than high-school pupils' self-control.

As regarding the self-reaction phase, 71.88% of the pupils think that they are good mathematicians, and 25.75% consider Mathematics difficult (Table 3). Pupils, who feel that they are good in Mathematics, tend to value Mathematics more than those pupils who have problems in learning Mathematics (Midgley, Feldlaufer & Eccless, 1988). This is shown also in this research, as it is a strong positive correlation between items "I like Mathematics" and "I am a good mathematician" and a strong negative correlation between items "I like Mathematics" and "Mathematics is difficult for me" (Table 8). 77.68 % of the pupils can solve their homework without help (Table 3). These pupils, because of the success they feel, like more Mathematics (Table 8). Pupils' self-judgment is high, 75.63% (see Table 3) of the pupils believe that if they practice more they will be better in mathematics and only 10.63% of the pupils think that no matter how much time they devote for studying mathematics, they can't improve their results. Primary school pupils' self-reaction is higher than secondary school pupils' and high-school pupils' self-reaction (see Table 6).

As regarding pupils' problem solving skills, the maximum points for each problem was 10; 5 points for the correct choice of the answer and 5 points for a correct logical reasoning. Pupils obtained an average 2.82 for the first problem and 2.24 for the second problem.

There is a mild correlation between pupils' self-control and problem solving skills, a weak correlation between pupils' attitude towards Mathematics and their problem solving skills (Table 7).

Conclusions

The results show that more than three quarters of 10-11 years old pupils like Mathematics, but only the half of them likes to solve non-routine problems. The positive attitude towards Mathematics is influenced by pupils' positive experiences on solving problems (i.e. success in solving the homework) and their beliefs in the utility of Mathematics in their future. Most of the pupils don't give up if they can't solve the problem, they go over the text again, they try to find similar worked examples, they ask for help.

There is a mild correlation between pupils' self-control and problem solving skills, a weak correlation between pupils' attitude towards Mathematics and their problem solving skills.

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